No. 2. — *Some Parasitic Worms in the Helminthological Collection of the Museum of Comparative Zoology*

By J. H. Sandground

I. Descriptions of some parasitic worms from *Solenodon paradoxus* Brandt (Insectivora)

Among the rarest of extant mammals are the two species of Solenodon, *S. paradoxus* Brandt, 1833 and *S. cubanus* Peters, 1861, which together constitute the very distinctive insectivore family Solenodontidae. Nocturnal in their habits, these fairly large, shrew-like animals live in subterranean galleries or in hollow trees and are restricted in distribution to heavily wooded mountains or rain forests on two islands in the Caribbean Sea. Although the small series of study specimens that it has been possible for a few of the world's largest museums to assemble indicates that these animals have always been difficult to procure, it is now generally supposed that with the development of agriculture in Cuba, the species *S. cubanus* has become extinct. Furthermore, since so few specimens of *S. paradoxus* have been secured on the island of Haiti, it was feared that this species had also suffered a similar fate. That this fear was not entirely warranted was proved by a German collector who, in 1935, succeeded in capturing 28 specimens in San Domingo.

Desiring specimens for particular anatomic studies, Professor George B. Wislocki of the Harvard Medical School commissioned the services of Mr. William J. Clench of the Museum of Comparative Zoology, who in the summer of 1937 was leading an expedition into the interior of the Republic of San Domingo. With the aid of native collectors, Mr. Clench was eventually successful in obtaining 3 adult specimens of *S. paradoxus*. Subsequently, while working on the formalin preserved body of one of these animals, Dr. Wislocki observed that the subperitoneal muscles of the pelvis were riddled with encysted parasites. These he kindly turned over to the writer, together with the viscera of this and another specimen. The muscle-invading parasites were found to be the larvae of an as yet unidentified thorny-headed worm (Acanthocephala) which I also found in large numbers attached to the mesenteries and diaphragm and encysted under the capsule of the liver and on the pericardium. Search of the intestine revealed numerous specimens of three other classes of parasitic worms: roundworms in the duodenum, masses of tapeworms in the lower part of the small intestine, and flukes in the colon.

In view of the rarity of the host it is not surprising that the literature of helminthology mentions no previous examination of *Solenodon*. Our studies indicate that at least two of the parasites belong to hitherto undescribed species. On the other hand, the trematode belongs to a genus whose many species are so similar in morphology, that I deem it undesirable to distinguish it with a new specific name.

The type material of the new species described in the following pages is deposited in the helminthological collection of the Museum of Comparative Zoology at Cambridge.

CESTODA

Hymenolepis wislockii spec. nov.

Numerous specimens of this tapeworm were found in the lower part of the small intestine. Small developmental forms ranging upwards in length from 4 mm. and consisting of a few growing proglottids and a scolex were plentiful in the upper jejunum and duodenum. The longest strobilae composed of several hundreds of narrow segments measure in the preserved state up to 80 mm. in length, with an average maximum width of 0.95 mm. Much shorter specimens are numerous. The scolex (fig. 1) presents a variable appearance according to the state of muscular contraction and the position of the rostellum which when everted from its spacious pouch forms a columnar protuberance 0.17 mm. in length and 0.15 mm. wide. Crowning the rostellum is a ring of from 38 to 40 hooks which measure 25 μ to 28 μ from the pointed blade tip to the base of the handle. The guard, about 9 μ long, projects almost parallel to the blade. Figure 2 depicts two hooks that were teased apart from the rostellum and manoeuvred into a single optical plane for camera lucida drawing. When the hooks remain in situ they may present a very different appearance and, depending upon the angle of vision, a wholly erroneous conception as to their size. Scolex about 0.35 mm. wide, with suckers from 0.11 to 0.13 mm. in diameter partially covered by a cuticular fold. Musculature well developed, there being 20 to 22 longitudinal bundles consisting of 7 to 10 muscle fibers in addition to the transverse muscle fibers. Ventral and dorsal excretory vessels pass ventral to the nerve cord and genital ducts. In immature segments the three developing testes lie in a transverse line; in more mature segments (fig. 3) the median testis is pushed forward on the aporal side. Cirrus sac measures 0.17 mm. by 0.06 mm. In addition to the seminal vesical coiled within the cirrus sac there is a voluminous external seminal vesical which in mature

segments extends to the middle of the segment and is persistent even in gravid egg-laden segments. Cirrus, devoid of spines, opens into a scarcely perceptible genital atrium near the middle of the segment margin. Ovary small, slightly lobed, situated mesially together with a very inconspicuous vitelline gland. There is an ampulliform dilation

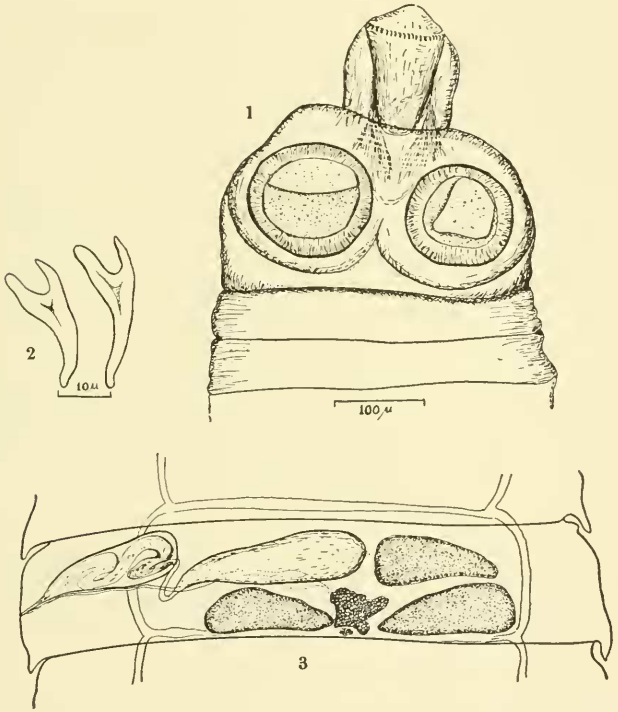

Fig. 1. *Hymenolepis wislockii* Sandground. Scolex with extruded rostellum.
Fig. 2. *Hymenolepis wislockii* Sandground. Isolated hooklets.
Fig. 3. *Hymenolepis wislockii* Sandground. Mature segment.

of the oviduct or receptaculum seminis situated ventral to the external seminal vesical. The vagina runs close to the posteroventral edge of the cirrus sac to open by the side of the cirrus. The uterus when fully formed spreads throughout the segment. The ova in utero in balsam mounts measure from 38 to 41μ by 30 to 35μ, but as found extruded naturally from the segment into the contents of the host's gut they measure 60 to 64μ by 46 to 50μ in outside diameter.

Species Relations

The genus *Hymenolepis* Weinland, 1858, is perhaps the largest in the entire field of helminthology, some 300 species parasitic in a wide variety of birds and mammals being attributed to it. In an effort to facilitate identification, Mayhew (1925) suggested a segregation of the members of this unwieldy group into 3 genera, but for reasons that have been given by several authorities (e.g. Fuhrmann 1932) these genera have had to be suppressed. In view of the magnitude of the genus and the difficulty of distinguishing many of its species on the basis of descriptions, it is common practise among present day workers to establish the taxonomic status of members by comparing it with those species that have been described from phylogenetically related hosts. The validity of this procedure depends upon the assumption of an ecologically, if not physiologically, determined specificity of the parasite for its host. Obvious as are the potential difficulties in adopting a procedure whose reliability is still largely theoretical, the exigencies of the moment are such that the practise cannot be abandoned, and consequently I shall restrict the discussion of the taxonomic status of the species described here to a comparison with the 30 species of Hymenolepis which have already been recorded from Insectivora. The names of these species together with the morphological features that are deemed of prime differential value are tabulated below.

In view of the plasticity of the body of tapeworms and the changes in topographic relations that the gonads may assume at different stages in growth as well as in death (depending upon fixation methods), the number and shape of the rostellar hooks has been found to provide the most reliable means of distinguishing between species of Hymenolepis. On this basis the species here described shows greatest resemblance to *H. bacillaris* (Goeze, 1782) and *H. tiara* (Dujardin, 1845)[1]. The present species, however, differs from both of the aforenamed species in its much larger cirrus pouch and the size of the eggs as well as in other features. It is consequently believed that the species is new, and it is named *H. wisloekii* as a token of my appreciation to the donor of the material.

[1] In this connection it may be noted that while *H. tiara* is stated by Baer (1928) to have 38 to 40 hooks, it is also described (Baer 1932) to have only 30 to 32 hooks. Whether this difference is an index of intraspecific variation or indicates the existence of two species remains to be shown.

DIMENSIONS OF SPECIES OF HYMENOLEPIS RECORDED FROM INSECTIVORA.[1]

Species	Host Genus	Locality	Length and Greatest Breadth of Strobila (millimeters)	Scolex	Suckers	Hooks (Number : Length)	Cirrus Sac	Eggs
alpestris, Baer, 1931	*Neomys*	Switzerland	7 by 0.36	.21 by .24	.07 by .13	absent	.08 by .03	
anthocephalus Gundy, 1935	*Blarina*	United States	40–100 by .3–.65	.25 by .39	.16 by .11	absent	.08 by .03	47 by 30μ
bacillaris (Goeze, 1782)	*Scalops*	United States						
	Talpa	Europe	150 by .15			36 : 20μ	.12	71 by 80μ
	Erinaceus	Europe						
barroisii Moniez, 1880	*Talpa*	Europe						
capensis Janicki, 1904	*Chrysochloris*	S. Africa	30 by 1.2					
chrysochloridis Janicki, 1904	*Chrysochloris*	S. Africa	(?) by .6	.29		16–18 : 29μ		27μ
diaphana (Cholodk., 1906)	*Sorex*	Russia	3 by .23			absent		
dodecantha Baer, 1925	"shrew"	C. Africa	15 by .57	.36 by .38	.095	12 : 32–34μ	.13 by .02	67 by 52μ
erinacei (Gmelin, 1790)	*Erinaceus*	Europe	160 by 1.9			20 : 17μ		
furcata (Stieda, 1862)	*Sorex*	Europe	10 by .34	.21	.08	22–28 : 28μ	.06 by .02	
globosa Baer, 1931	*Neomys*	Switzerland	2 by .19	.29	.18 by .08	absent	.01 by .02	38μ
jacobsoni Linstow, 1907	*Pachyura*	Asia	34 by 1.2			10 : 21μ		
maclaudi Joyeux et al, 1928	*Crocidura*	W. Africa	25 by 1.0	.35	.10	23 : 36μ	.12 by .05	72 by 40μ
macroscelidarum Baer, 1925	*Macroscelides*	S. Africa	34 by 2.0	.23	.08	20 : 19–21μ	.13	36μ
magnirostellata Baer, 1931	*Neomys*	Switzerland		.26	.14	20–24 : 30μ	.14 by .05	42 by 30μ
minutissima Meggitt, 1927	*Crocidura*	India	2 by .5	.12		12 : 16–18μ		
moniezii Parona, 1893	*Pteropus*	Asia				absent		
neomidis Baer, 1931	*Neomys*	Switzerland	8 by .19	.3 by .4	.15 by .08	18 : 22μ	.10	
petrodromi Baer, 1933	*Petrodromus*	S. Africa	20 by .95			10 : 11–13μ	.15 by .03	
peipingensis Hsü, 1935	*Talpa*	China	750 by 1.9	.26	.11 by .09	absent	.21 by .05	
pistillum (Dujardin, 1845)	*Crocidura*	France	2 by .3	.17	.05	14–22 : 14μ	.06	62 by 48μ
	Sorex							
polyacantha Baer, 1932	*Neomys*	Switzerland	18 by .13	.38	.16	62 : 15–16μ	.08 by .02	38 by 27μ
scalaris (Dujardin, 1845)	*Crocidura*	France	34 by 1.2	.48	.90	10–13 : 21–33μ	.07	70 by 40μ
	Sorex							
singularis (Cholodk., 1912)	*Sorex*	Russia	2.5 by .3	.50	.14 by .11	10 : 62μ	.76 by .02	53 by 42μ
solitaria Meggitt, 1927	*Crocidura*	India				16 : 17μ		
soricis Baer, 1925	*Sorex*	France	0.3 by .08	.13	.07 by .06	absent		
spinulosa (Cholodk., 1906)	*Sorex*	Russia	30 by .5	.30	.09	18–20 : 37μ	.03	46μ
tiara (Dujardin, 1845)	*Sorex*	Europe	30 by .7	.30	.05	38–40 : 26μ	.08	34μ
	Crocidura							
toxometra Baer, 1932	*Sorex*	Switzerland	6 by .24	.21	.12	10 : 35μ	.04	42μ
uncinata (Stieda, 1862)	*Sorex*	Switzerland	15 by .56	.32	.10	18–22 : 17–22μ	.04	56μ
wislockii mihi	*Solenodon*	San Domingo	80 by .95	.35	.11	38–40 : 28μ	.17	64 by 50μ

[1] The data here tabulated have been assembled from original as well as secondary sources. The dimensions of certain species as given by different authors vary considerably, but it is impossible to determine whether this is to be ascribed to a confusion of the species or to a natural intra-specific variation. In view of the limitations of space, only maximum figures are usually presented in this table. Species that have already been relegated to the synonymy are not included.

TREMATODA

Brachylaemus sp.

From the colon of one of the two specimens of *Solenodon paradoxus* dissected, eleven greyish colored flukes were recovered. These small worms in the preserved condition are almost round in cross section; the two bluntly attenuated extremities tend to bend ventrally so that from the side the worms are crescentic in shape. The pressure used in flattening specimens for the preparation of toto mounts causes a slight increase in width and may also derange other proportions of the body. The following measurements were all taken from toto mounts (fig. 4). Length 2.2 to 2.85 mm. Breadth at widest point 0.65 to 0.75 mm. Cuticle over preacetabular zone ornamented with minute spines. The spinosity is more difficult to detect in some individuals than in others. Oral sucker circular to elliptical in outline with diameter ranging from 0.25 to 0.35 mm. The mouth opening is partially covered by a fold of cuticle. Pharynx more or less spherical, 0.16 to 0.18 mm. in cross section. Intestinal crura bend anteriorly around the pharynx and subsequently run a very sinuous course, partially covered by the uterine coils, practically to the caudal extremity. Acetabulum, at junction of anterior third of body, 0.27 to 0.31 mm. in diameter. The short main stem of the excretory vesical opens subterminally on the ventral surface. Vitellaria, consisting of a narrow band of follicles, extend from the posterior level of the acetabulum to the level of the anterior testes; the transverse vitelline ducts dilate to form a conspicuous reservoir crossing the ovary. Unsatisfactory fixation and the thickness of our specimens make for poor differential staining so that for the determination of the relationship of the genital ducts it has been necessary to rely largely upon serial sections. The gonads lie tandem in the median axis in the posterior quarter of the body with the ovary situated between and practically contiguous with the testes. The testes and ovary are all regular in outline; the latter organ (0.18 to 0.25 mm. in diameter) is only slightly smaller than the two testes. Even though Odhner's definition of the Brachylaemidae mentions the absence of a receptaculum seminis, our sections reveal a thin-walled sperm-containing dilation of the complex of ovarian ducts, just below the ovary. This we can only interpret as a seminal receptacle. Baer (1928), Werby (1925), and others have also depicted a receptacula seminalis in various species of this genus, but Joyeux et al (1934) deny its presence, interpreting the structure as an elongate oötype. No trace of Laurer's canal was seen. The uterus is very

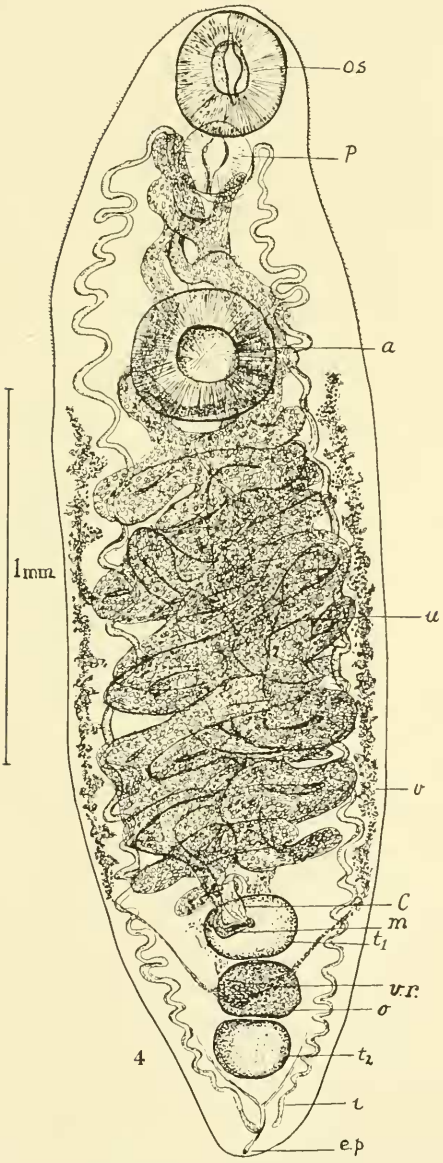

Fig. 4. *Brachylaemus sp.* Ventral view of toto-mount.

Abbreviations: o.s.–oral sucker, p.–pharynx, a–acetabulum, u–uterus, v–vitellaria, c–cirrus organ, m–metraterm, t_1 and t_2–testes., o–ovary, i–intestinal caeca, e.p.–excretory pore.

voluminous, its coils (containing countless golden color eggs which measure 13–16μ by 24–28μ) extend beyond the acetabulum to the region of the pharynx. The metraterm and the cirrus pouch open into a common genital atrium, which is situated in the median ventral line well in the zone of the anterior testis. In toto mounts the genital pore is placed over the center of the testes; in lateral view it opens ventrally at the side of the testes.

Systematic Relations

Members of the genus *Brachylaemus* (syn. *Harmostomum*) are very muscular, and in life the body is capable of considerable extension, more especially in the anterior region. They lose their motility soon after the death of their host and the body contracts markedly, sometimes producing superficial wrinkling. Not only do measurements become a poor criteria of the species as a result of variations in contraction, but the intestinal caeca take on undulations and the position of the genital pore relative to the anterior testis may be altered. The morphology of the organs varies apparently also with the state of maturity. As a consequence of these variations, the identification of species becomes a very difficult matter as attested by Dollfus (1934 and 1935) and by Joyeux, Baer and Timon-David (1934), who have recently assayed a revision of the genus, whose representatives are found in several orders of birds as well as in 3 orders of mammals.

The names of eleven species parasitizing members of the Insectivora are listed in the key catalogue of Stiles and Stanley (1932). Although many of these have been placed in synonymy by Baer (1928) and by Dollfus (1934), considerable uncertainty still exists regarding the validity of the remaining species. While it is to be hoped that life history studies will eventually elucidate the taxonomic status of many, the demonstrated fact that at least some species do not exhibit a high order of host specificity will not tend to reduce the existing uncertainty (see Krull, 1933 and Dollfus, Callot and Desportes 1935). Rather than complicate the already perplexing problem I think it desirable to ascribe no specific name to the species here described. It may however be noted that the species does not appear to differ significantly from *B. helicis* (Meckel, 1846) as recently described by Baer (1928) from European hedgehogs, nor from the species *B. opisthotrias* (Lutz, 1895) from South and North American opossums, as described recently by Dickerson (1930).

NEMATODA

Shattuckius shattucki gen. et spec. nov.

Slender worms disposed to be loosely coiled in two or three whorls. Cuticle very faintly striated transversely and more conspicuously marked by about 16 longitudinal lines or elevated crests. There is an asymmetric inflation of the cuticle of the head for a distance of about 0.075 mm. (fig. 5). Cervical papillae apparently absent. Buccal

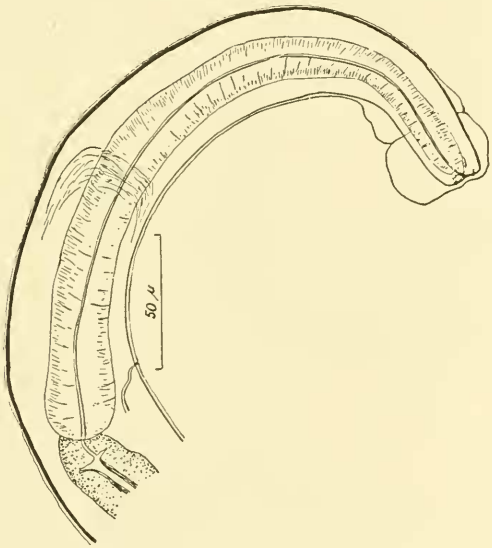

Fig. 5. *Shattuckius shattucki* Sandground. Anterior extremity.

cavity vestigial; without obvious lips but surrounded by 4 cephalic papillae. Oesophagus claviform, 0.31 mm. and 0.34 mm. long in male and female respectively; encircled by nerve ring near its middle.

Male 3.3 to 3.5 mm. long and 0.075 mm. maximum width. Female 5.4 to 5.7 mm. long with 0.085 mm. maximum width. Tail of female (fig. 6) 0.11 to 0.12 mm. long with a spinous process at its bluntly rounded tip. Vulva located 1.3 to 1.4 mm. from the caudal extremity; the cuticle around its rim (fig. 7) is slightly inflated making the vulva fairly conspicuous. Ovejectors about 0.16 mm. long. Eggs with very thin shells measuring in utero 48 to 50 μ by 32–35 μ.

Bursa of male (fig. 8) relatively spacious. There is a distinct though small dorsal lobe. Lateral lobes adorned with a punctate striation

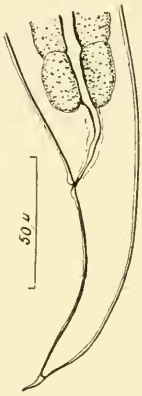

Fig. 6. *Shattuckius shattucki* Sandground. Tail extremity of female.

along their internal postero-lateral margins. There is a small accessory membranous lobe, apparently devoid of supporting ribs. Prebursal papillae and telamon apparently absent. The long, relatively slender

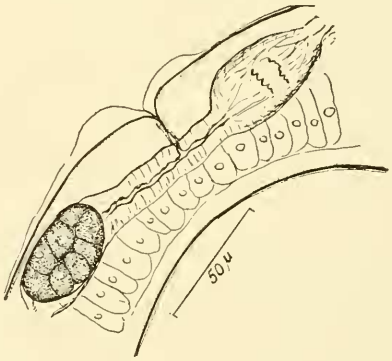

Fig. 7. *Shattuckius shattucki* Sandground. Region of vulva.

externo-dorsal ray originates from a common trunk with the robust dorsal ray and is the only ray that does not extend to the margin of the bursa. The dorsal ray gives off serpentine lateral rays before

bifurcating. On each branch of the divided dorsal ray, at about the mid-point there is an external bud, representing a vestigial digital process. Lateral rays about equal in size and well separated from each other. Ventral rays subequal, divergent from their common trunk to the bursal margin. Spicules (fig. 9), equal in size, about 70μ long, sparsely punctate on their surface. They are of unusually simple form,

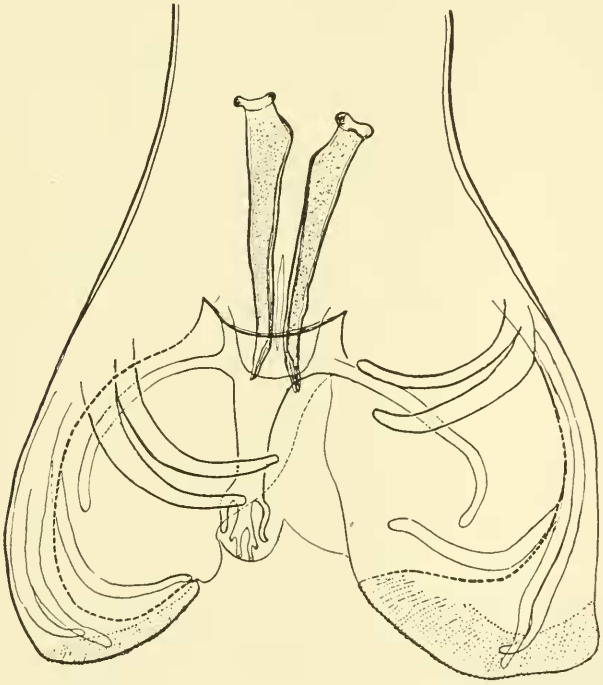

Fig. 8. *Shattuckius shattucki* Sandground. Posterior extremity of male.

devoid of lateral angular prominences and having only a single, very faint crest running longitudinally. It requires the highest possible magnifications to show that the spicule tips do *not* terminate in simple, acute points, but that they are cleft for a short distance to present two or possibly three splinter-like processes united by a transparent membrane. There is a very faintly cuticularized gubernaculum about 25μ in length. *Systematic Relations.* From Stiles and Stanley's Key Catalogue (1932) we learn that the only representatives

of the Trichostrongylidae recorded from the Insectivora are a number of species of *Viannaia* (Heligmosominae). The parasite described above, therefore, appears to be the first didelphous form, or member of the subfamily Trichostrongylinae, to be reported from this order of mammals. A review of the literature indicates that our species is clearly a new form, but, because the number of genera in the Trichostrongylinae has been multiplied to such an extent by recent workers, the establishment of its taxonomic affinities has not proved simple. Superficially the species appears to be related to *Cooperia*, but the spinous process that tips the tail of the female and the subequality in size of the ventro-ventral and latero-ventral rays as well as other

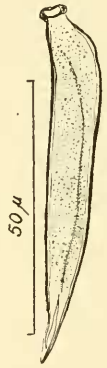

Fig. 9. *Shattuckius shattucki* Sandground. Spicule isolated by dissection.

characters, immediately separate it from members of this genus. In respect to these same features it appears to show greater resemblance to the genera *Molineus* Cameron, 1923 and *Maciella* Travassos, 1935. From both of these genera, however, it differs in the division of its dorsal ray and in the relatively plain structure of its spicules. We should prefer to regard characters of this order as having no more than specific value, in this way avoiding the oftentimes dubious creation of new genera, but the taxonomic standards that have been so generally adopted leave no alternative but to create a new genus which I name in homage to my colleague Dr. George C. Shattuck and briefly define as follows:

Trichostrongylinae. Cuticle faintly striated transversely, and with about 16 longitudinal crests. With asymmetrical cephalic inflation

but without cervical alae or cervical papillae. Vestigial buccal capsule. Female with mucronate tail; vulva postmedian. Eggs segment in utero. Bursa ample, with distinct dorsal lobe. Internal surface of lateral lobes ornamented along posterior borders. A very small accessory membrane present. Ventro-ventral and latero-ventral rays subequal and extending to bursa margin. Lateral rays about equally

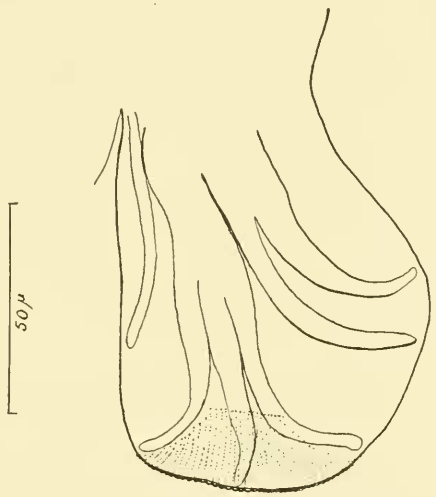

Fig. 10. *Shattuckius shattucki* Sandground. Lateral lobe of the bursa with supporting rays.

long and well separated. External-dorsal, long and slender, but not attaining margin, arises from common trunk with the massive dorsal ray. Dorsal gives off lateral branches before bifurcating into two halves, each of which has a small aborted process near its middle. Spicules relatively regular in outline, with well developed knob cephalad and cleft terminally into two or three parallel splinters. Gubernaculum acicular, very poorly chitinized. Prebursal papillae apparently absent.

Genotype. *S. shattucki.*

Habitat. Duodenum of *Solenodon paradoxus*, Santo Domingo.

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2. A redescription of TETRAPETALONEMA DIGITATA (Chandler, 1929) comb. nov., a filariid parasite of Gibbon Apes, with an enumeration of its congeners.

Under the designation *Dirofilaria* (?) *digitata*, n. sp., Chandler (1929) described three female filariid nematodes found in the abdominal cavity of a *Hylobates hoolock*, which had died in the Calcutta Zoological Garden. In 1933, the present writer recorded the occurrence of the same species in an Annamese gibbon, *Hylobates leucogenys* from French Indo-China, but again because of the absence of male worms it was not possible to erase the mark of interrogation originally inserted by the discoverer of the species to emphasize the element of uncertainty in his generic designation.

Recently the Museum received a collection of parasitic worms that, in an incidental way, had been secured by the Asiatic Primate Expedition under the leadership of Harold J. Coolidge, Jr. In the collection were specimens of *Dirofilaria pongoi* Vogel and Vogelsang, 1930, taken from (1) an orang-utan, *Pongo pygmaeus* and (2) *Hylobates funereus*[1] at Abai, in N. Borneo. Also there were several bottles containing very large numbers of Chandler's above-mentioned species which forms the subject of the present paper. This parasite had been found in a majority of adult gibbons, *Hylobates lar entelloides* (Geoffroy) taken at an altitude of 1000 m. on Mt. Intanon, near Cheingmai in northern Siam. At lower altitudes and in other portions of their range, the gibbons appeared to be free of filariasis. The collectors were greatly impressed by this epidemiological observation, and were also surprised that no signs of disease was manifested by apes so heavily infected that the peritoneal cavity and sometimes also the pleural cavity appeared to be crammed, "like a bowl of vermicelli" with crawling masses of worms.[2]

A study of this abundant material now enables us to describe for the first time the male of Chandler's *D. digitata* and to transfer the species to the genus *Tetrapetalonema*.

[1] This appears to be the first record of *D. pongoi* in a gibbon.

[2] From the field notes of Professor A. H. Schultz of Johns Hopkins Medical School, and Dr. C. R. Carpenter of Bard College, two members of the expedition, we learn that infants (i.e. under one year of age) were rarely infected; 12 of 19 juvenile gibbons carried sparse infections, while only two out of eighty adults were apparently free of filariid worms. In two of the latter it was noted that the ovaries were cystically enlarged with worms penetrating into the substances of the organ. In contrast with the high incidence and great intensity of infection with *T. digitata* that was encountered in gibbons captured in the forests, it was found that families of the same host species that lived segregated outside of the forest were free of infection. It seems possible that this observation may have special significance from the standpoint of the probable insect vector of the parasite.

We desire here to express our appreciation to Dr. O. E. McCoy of the University of Rochester, New York, who presented to the Helminthological Collection of our Museum valuable specimens of *T. marmosetae* Faust, 1935, *T. atalensis* McCoy, 1936, and *T. parva* McCoy, the three species at present embraced in the genus. The examination of this material has been of great aid in considering the taxonomic status of the forms involved.

Tetrapatelonema digitata (Chandler, 1929)

The following account is based on a study of more than twenty representatives of each of the sexes taken from several specimens of the host.

Conforming with its congeners, this species is a very slender, thread-like worm. A marked attenuation of the body commences at an appreciable distance from the extremities. The flagelliform nature of the head and tail ends thus produced is more conspicuous in this species than in those described from New World monkeys. There is no noticeable guttural dilatation or annular swellings in other parts of the body such as are characteristically found in *T. marmosetae* and *T. atalensis* (cf. McCoy, 1936).

Although the cuticle in this genus has invariably been described as smooth or unstriated, close examination of specimens of probably all species which have not been subjected to complete clearing will show that the cuticle is striated with very fine lines at about 1.5μ intervals.

The anterior end of the body is bluntly rounded and about 30μ wide in *T. digitata*. There is no semblance of a reinforced integumentary shield, cuticularized cap or analogous cephalic ornamentation such as is found in some of the genera that have incorporated in the subfamily Setariinae of Yorke and Maplestone. In a frontal view of the head (fig. 11) as well as in lateral view (fig. 12), eight delicate cephalic papillae in the subdorsal and subventral positions can be made out. They are arranged in a manner common among genera in the Filariidae. Although in frontal view the papillae may appear to be almost contiguous, they are actually well separated and it would be misleading to describe them as "twinned papillae at each corner of a rectangular peribuccal plate," whereby the inference could be drawn that, by a process of approximation or fusion, the papillae have been doubled, in analogy with the "double papillae" frequently seen on the lips of ascarids.

The lateral papillae, or, more correctly, amphids, are in the form of

minute slit-like organs which are rather difficult to discern on the surface of the cuticle. These organs have by error been described by both

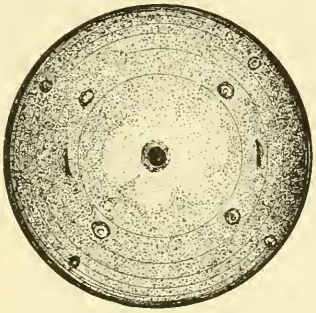

Fig. 11. *Tetrapetalonema digitata.* Frontal view of head.

Faust and McCoy as located in the mid-dorsal and mid-ventral fields.

The minute oral aperture is simply a rounded pit without an elevated rim. It is difficult to get a clear impression of the structure of the

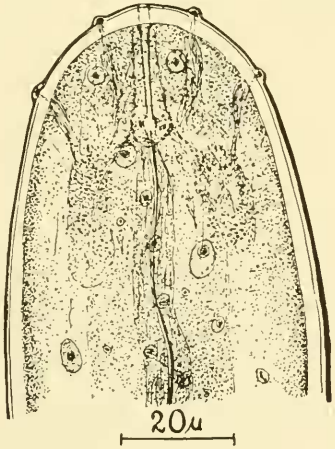

Fig. 12. *Tetrapetalonema digitata.* Anterior extremity in lateral view.

alimentary canal immediately behind the mouth owing to the region being obscured by strands of nerve fibers, glandular cells and other subdermal structures. Yet, in translucent specimens examined after

minimal clearing, the presence of a relatively refractile, tubular structure, about 25 μ in length is to be made out. This structure is in favorable specimens quite discrete, and is to be interpreted as a vestigial or rudimentary buccal capsule; it sometimes appears to be protrusible and may function as a piercing organ or stylet. Its presence is described or illustrated in some of the other species which we attribute to this genus (e.g. *Parlitomosa zakii* Nagaty), and upon its existence depends our views as to the taxonomic affinities of the genus.

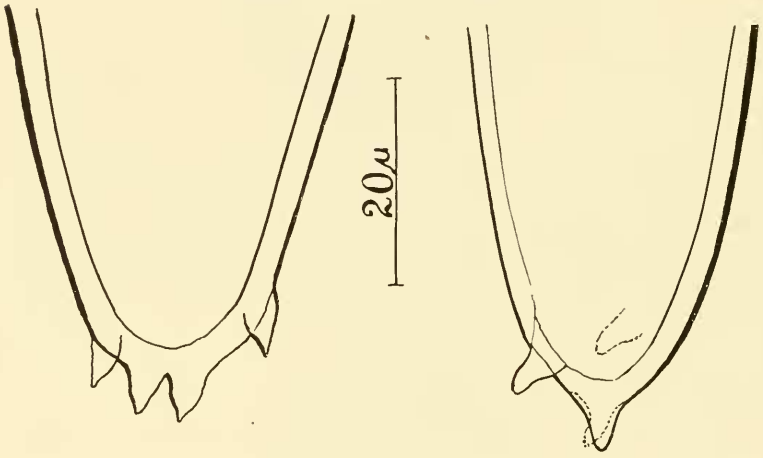

Fig. 13. *Tetrapetalonema digitata.* Posterior extremity of female; ventral and lateral views.

The alimentary canal throughout its length is weakly developed. It is especially difficult to describe the oesophagus (which is only about 20 μ wide) when the specimens are completely cleared in lacto-phenol solution or glycerin. Faust's and McCoy's descriptions omit all reference to the alimentary canal. Chandler described the oesphagus of the species *digitata* as "very fine and slender, only about 11 μ in diameter and not easily observed except where it is bent and runs at an angle to the long axis of the body. The junction with the intestine is not sharply demarcated, the intestine tapering, cone-like, to the junction with the oesophagus." Only by attempting to follow the course of the lightly cuticularized lining of the oesophagus to the point where it appears to end and where the coarser granulation of the intestinal cells commences does it appear possible to determine the

approximate length of the oesophagus in our material. In the females this point is more difficult to detect than in male worms because the muscular dilatation of the vagina obscures the oesophago-intestinal

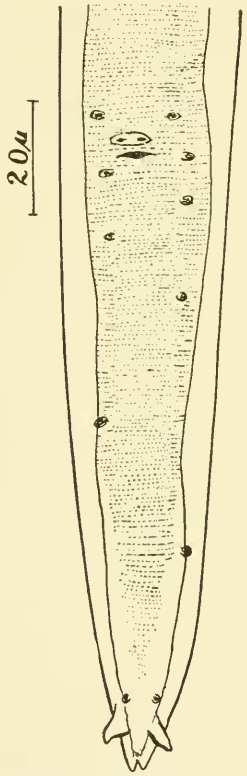

Fig. 14. *Tetrapetalonema digitata*. Caudal region of male, ventral view, showing distribution of papillae.

junction. Consequently measurements of the oesophagus are no better than approximations which can be accorded no critical values.

The vulva is not salient, but the massive vaginal chamber, or ejector, allows its position to be easily located. The vagina runs a rectilinear course posteriad for 2 to 3 mm. and then divides into two uteri that are packed with microfilariae. As expressed from the uteri the fully developed larvae measure in watery solution from 170 to 188 μ

in length and about 4μ in width. They are without a sheath and the posterior region tapers to a blunt end. Owing to the lack of suitable

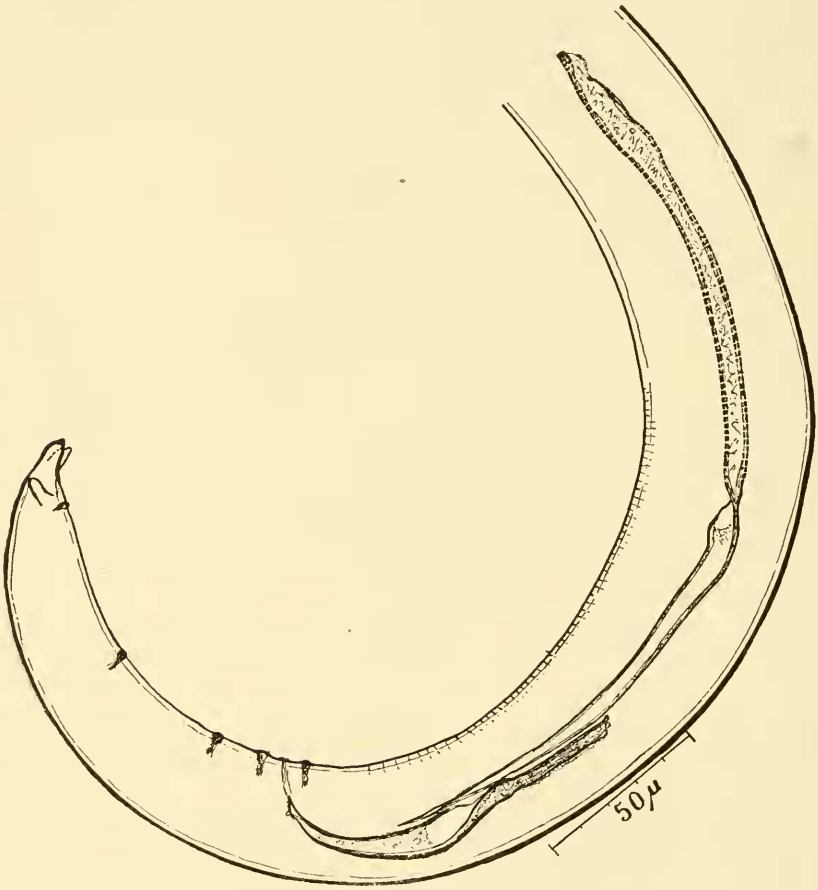

Fig. 15. *Tetrapetalonema digitata.* Caudal region of male, lateral view, showing characteristic shape of the spicules.

blood smears we cannot describe the finer details of the microfilaria morphology.

The anus in the female has a rudimentary appearance indicating, perhaps, functional atrophy. The tip of the tail has a shallow cleft,

and is ornamented by a pair of cuticular lappets, about 4μ in length, which originate on the subventral surface (fig. 13).

In the preserved state the tail of the male is disposed in a loose two-looped spiral. The structure of its tip is essentially the same as described for the female. There are very narrow lateral expansions of the cuticle suggesting caudal alae, but these appear to be artefacts which are visible only when the tail is flattened by pressure from the cover-glass. The caudal papillae are very minute, sessile and subventrally situated. Usually they number three pairs in the peri-cloacal zone, one pair mid-caudal in position and a fifth pair immediately in front of the terminal lappets. As in many filariid species, the caudal papillae are subject to a degree of numerical irregularity and they are often asymmetrically disposed (fig. 14).

The spicules have specifically distinctive forms illustrated in figure 15. The "shaft," or proximal cylindrical portion, of the left spicule is as long or slightly longer than its more filamentous, leash-like, distal portion. The right spicule resembles a sickle in having a well defined "handle" and an arcuate "blade." In none of our specimens did we find the spicules exserted so as to permit the examination of their extremities. In this connection it may be of interest to note that the relatively long, filiform, left spicule in other species of the genus always appears to be extruded in fixed material.

There is no trace of a cuticularized accessory piece or gubernaculum.

The dimensions of *T. digitata* are given in the appended table.

Taxonomic Relations

As mentioned in our introduction, prior to the present re-allocation of *D.* (?) *digitata* Chandler, three species had been definitely assigned to *Tetrapetalonema* which, imputed to be closely allied to the genus *Dipetalonema*, has been referred to the Setariinae.

A survey of the recent helminthological literature allows us to transfer an additional three species to Faust's genus: (1) *T. nieollei* (Mazza, 1929) and (2) *T. tenuis* (Mazza, 1929) both parasites of *Cebus* spp. from the northern "chaco" of Argentina; (3) *T. zakii* (Nagaty, 1935), a parasite of the Brazilian *Leontocebus rosalia*.

It is not improbable that other parasites of primates incompletely described as species of Filaria by early helminthologists such as Molin may also be members of *Tetrapetalonema*. Furthermore, it is possible that *Tetrapetalonema* is a synonym of *Mansonella* Faust, 1929, whose type and only species, *M. ozzardi* (Manson, 1897) parasitic in man in

the Neotropical region, has been very insufficiently described on the basis of the female worms, which are very tenuous and have tails carrying minute lappets resembling the structures found in *Tetrapetalonema spp.*

In describing *Parlitomosa zakii*, a species that appears to be very closely related to *T. marmosetae*, Nagaty (1935) referred his new genus to the Filariinae and compared it with such genera as *Litomosa, Macdonaldius, Ackertia*, etc. In a more comprehensive review than we are at present able to undertake, several of these recently proposed genera, whose differentiation is rather indefinite, will have to be taken into account.

In this paper our consideration will be confined to those species of *Tetrapetalonema* that have been named above. In so far as several of these have been described in journals that are not widely accessible, it has been deemed desirable to present in tabular form that facilitates comparison, such measurements of the species as have been provided in the original descriptions.

Among many groups of parasitic nematodes, particularly those belonging to the Filariidae, differences up to 100% or even more in the gross size of individual worms, supposedly belonging to a single species, are not rare. Even the dimensions of the spicules and the proportionate length of such organs as the oesophagus are often subject to considerable variation. The taxonomic significance of divergencies such as these has been well recognized by some helminthologists, but their evaluation is difficult. Only by securing material from controlled experimentally induced infections does it appear possible to determine whether these variations are inherent in the constitution of individual worms without reference to any influence that the environment (involving such factors as unfavorable host species, etc.) may exert upon growth, or whether the differences are due to random samplings of worms of different ages, whose growth does not cease with the attainment of sexual maturity. For the critical student of helminthology, at least a notion of the extremes in the variation range is desirable before commensural data can be accepted as valid differential criteria for species that have not been distinguished from their congeners on a structural basis of constant nature.

As the accompanying table shows, although the dimensions in some species of *Tetrapetalonema* show appreciable variation, no indication of the size range is available for at least four of the seven supposedly distinct species. On the basis of present figures, three species (namely: *T. digitata, T. marmosetae* and *T. parvum*) appear to be separable on

TABLE

Species	*digitata*	*marmosetae**	*zakii*	*atatalensis**	*parvum**	*nicollei*	*tenuis*
Author	Chandler, 1929	Faust, 1935	Nagaty, 1935	McCoy, 1936	McCoy, 1936	Mazza, 1929	Mazza, 1929
Males							
Length	100–130	26–45	41	32	16.5–19	93	30
Maximum width	0.23–.27	0.07–.10	0.11	0.08	0.07	0.25	0.09
Length oesoph.	1.1–1.46		0.33	0.55			
Length tail	0.11–.12	0.10–.11		0.08	0.08	0.06	0.07
Spicule right	95–120 μ	180 μ	49 μ	220 μ	140 μ	300 μ	
Spicule left	250–310 μ	660–720 μ	350 μ	770 μ	640 μ	1000 μ	
Females							
Length	220–260	70–117	105	49–63	28–49	209	74
Maximum width	0.46–.55	0.17	0.2	0.15	0.17	0.6–.8	0.25
Length oesoph.	ca. 1.1			ca. 0.85			
Vulva from head	0.95–1.2	0.86–1.0	0.71	0.8–.93	0.5–.68	1.8	0.85
Length tail	0.33–.46	0.2–.32	0.1–.16	0.16–.2		0.3	0.35
Microfilaria	170–188 μ	299 μ	306–342 μ	205 μ	187 μ		
Host.	*Hylobates hoolock*, *H. leucogenys*, *H. lar*	*Leontocebus geoffroyi*, *Saimiri örstedii*.	*Leontocebus rosalia*	*Ateles geoffroyi*, *A. dariensis*	*Cebus capucinus*, *Saimiri örstedii*	*Cebus azarae*, *C. libidinosus*.	*Cebus libidinosus*

*These measurements have been extracted from the original descriptions and are supplemented by additional measurements made by the present author from specimens identified by Dr. O. R. McCoy.

commensural data. However, some of these species may be distinguished on criteria that are of greater taxonomic value than length. Thus in our experience, *T. digitata* may be recognized by the characteristic form of both spicules in the male, the right spicule, for example, being sickle-shaped and more easily seen than in *T. marmosetae*, *T. atalensis* and *T. parva*. On the other hand the buccal vestibule in *T. atalensis* is a well developed organ of characteristic shape (figure 16) which may be contrasted with the cylindrical, more or

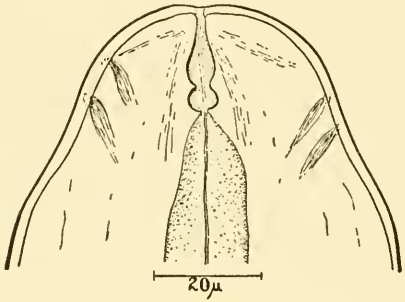

Fig. 16. *Tetrapetalonema atalensis* McCoy. Anterior extremity in lateral view showing buccal capsule.

less diaphanous buccal capsule in the species *parva*, *marmosetae* and *digitata*. Furthermore, according to McCoy, the size of their respective microfilariae affords another means of distinguishing between certain of the species.

Without recourse to authentically identified specimens it is not possible to venture an opinion on the status of *T. zakii*, *T. nicollei* and *T. tenuis*. The descriptions of the two last mentioned species leave much to be desired. Their taxonomic integrity, and, hinging upon this, the nomenclatural status of other species in the genus, including the genotype, will remain in doubt until more complete descriptions are forthcoming.

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3. Setaria hyracis Baylis, 1932, a synonym of S. loveridgei Sandground, 1928

In 1928 I described *Setaria loveridgei* n.sp. on the basis of a few filariid nematodes that Mr. Arthur Loveridge had collected in Tanganyika from the hyrax, *Procavia brucei prittwitzi* at Dodoma, Tanganyika Territory. Four years later, Baylis (1932) described what appeared to be a second species of this genus, *S. hyracis* from a tree dwelling hyrax, *Dendrohyrax sp*, of the Belgian Congo (Sakuru), differentiating his species from *S. loveridgei* on such criteria as the smaller size, longer spicules and differences in the number and arrangement of the caudal papillae in the male.

In more recent years I have had occasion to identify specimens of *Setaria* taken from *Procavia brucei frommei, P. scheffleri* and *Dendrohyrax* (?) *arboreus* collected in various localities in Kenya Colony, Tanganyika and the Belgian Congo. As a result of these studies I have come to the conclusion that all of the material from the above named hosts comprised a single but highly variable species, presumably to be identified with *S. hyracis*. However, a re-examination of the type specimens of *S. loveridgei* has shown that a serious error was made in my original description of the spicules of this species.

The material upon which the description was based was extremely dark in color and even bleaching in hydrogen peroxide failed to render the two male worms as translucent as was desirable. In the male worm that was chosen as type, the right spicule was partially exserted. Re-examination has shown that what I originally took to be two spicules closely applied to each other along one side, is actually nothing more than the exceptionally broad proximal part of the right spicule, whose distal extremity was broken off; the right spicule, situated a considerable distance further forward was overlooked on account of the poor visibility. A study of the second male specimen shows the spicules to be of essentially the same form and size (right; 0.25 mm.; left; 0.59 mm.) as described by Baylis for *S. hyracis* and as found in specimens from other species of hyrax. With these specimens, also, *S. loveridgei* coincides in the general pattern of male caudal papillae and the appearance of the tooth-like projections in the circumoral ring, although it should be noted that the variation in the appearance of this structure is comparable with that described for *S. hornbyi* by Thwaite (1927).

As with many other members of the Filariidae, great disparity is to be found in the length of specimens of *Setaria loveridgei* from different

species of hosts. In our first lot of material from *Procavia brucei*, the two males measured respectively 135 and 160 mm.; from *P. scheffleri* male worms vary in length from 100 mm. to 115 mm.; a single male taken from *Dendrohyrax* (?) *arboreus* is no longer than 65 mm. In the absence of any other taxonomically significant differences in these worms, it appears safest to regard them as intra-specific variants.

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